(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 242 127**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 87303097.7

(22) Date of filing: 09.04.87

(51) Int. Cl.[4]: **B 60 K 41/02**

(30) Priority: 09.04.86 JP 83121/86

(43) Date of publication of application: 21.10.87
Bulletin 87/43

(84) Designated Contracting States: DE GB IT NL SE

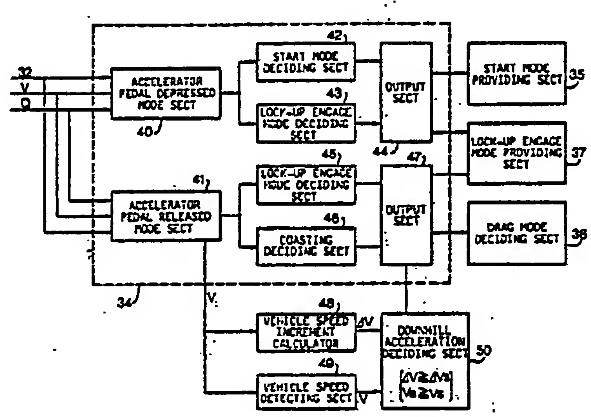
(71) Applicant: FUJI JUKOGYO KABUSHIKI KAISHA,
7-2 Nishishinjuku 1-chome Shinjuku-ku, Tokyo (JP)

(72) Inventor: Ohkumo, Hiroya, 2-3-10 Nukuiminami-cho,
Koganei-shi Tokyo (JP)
Inventor: Sakakiyama, Ryuzo, 1-21 Takamatsu,
Toshima-ku Tokyo (JP)

(74) Representative: Shindler, Nigel et al, BATCHELLOR, KIRK & EYLES 2 Pear Tree Court Farringdon Road, London EC1R 0DS (GB)

(54) System for controlling a clutch for a vehicle.

(57) A system for controlling a clutch current of an electromagnetic clutch of a vehicle when the vehicle accelerates downhill. The clutch is normally engaged when vehicle speed is higher than a first reference speed. When the vehicle accelerates downhill at a speed higher than a second reference speed which is lower than the first reference speed, the clutch is engaged to provide an engine braking effect.



EP 0 242 127 A2

Best Available Copy

"System for Controlling a Clutch for a Vehicle"

The present invention relates to a system for controlling a clutch for an automatic transmission of a motor vehicle.

An automobile provided with a continuously variable belt-drive transmission with an electromagnetic clutch is disclosed in EP-A 151038. The electromagnetic clutch of the transmission is controlled by a control system to provide various operational modes such as a starting mode of a vehicle, reverse excitation mode, drag mode, mode of lock-up engagement. One of the modes is selected in accordance with a position of a selector lever and driving conditions to control the electromagnetic clutch.

In the above described control system, the vehicle speed at which the clutch is engaged is set at a relatively high level so as to enhance coasting of the vehicle. Accordingly, when the vehicle coasts downhill at a speed lower than the cluth engaging speed, the vehicle may accelerate although the accelerator pedal is not depressed.

Such acceleration of the vehicle downhill is not critical in ordinary conditions. However, for example, on a snowy or icy hill it is desirable that the clutch is engaged in the low vehicle speed range so as to effect the engine braking and prevent coasting. However the clutch-engaging vehicle speed is set at such a high level in the conventional system, that the vehicle tends to accelerate up to a high speed without engine braking.

Japanese Patent Laid Open 60-157930 proposes a control

system wherein once the vehicle speed reaches a speed for the engagement of the clutch while the accelerator pedal is released (i.e. the vehicle is coasting downhill), the clutch engaging vehicle speed at which the clutch is engaged is changed to a lower speed. Thus, engine braking is effective at a low vehicle speed.

However, in such a system, when the vehicle is accelerated after starting of the vehicle without depressing the accelerator pedal, the clutch is not engaged until the normal high speed. Thus, the vehicle may be accelerated up to a high speed.

The present invention seeks to provide a system for controlling an electromagnetic clutch wherein sufficient engine braking effect can be achieved when driving downhill even at relatively low vehicle speed.

According to the present invention, there is provided a system for controlling a clutch for a motor vehicle, wherein the clutch is normally engaged when vehicle speed is higher than a first reference speed, the system comprising:

first detecting means for detecting release of the accelerator pedal of the vehicle and for producing a corresponding release signal;

second means for detecting acceleration of the vehicle in the presence of the release signal and for producing an acceleration signal;

third means for detecting engine speed and for producing a downhill acceleration signal when the engine speed is higher than a second reference speed which is lower than the first reference speed;

and means responsive to the downhill acceleration signal for engaging the clutch.

One embodiment of the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a schematic illustration of a system for controlling an electromagnetic clutch for a motor vehicle;

Figures 2a and 2b show a block diagram of a control unit according to the present invention;

Figure 3 is a graph showing regions of various modes;

Figure 4 is a block diagram of a main part of the system according to the present invention;

Fig. 5 is a flow chart showing the operation of the system;

Fig. 6 is a graph showing variation of clutch current.

Referring to Fig. 1, the crankshaft 10 of an engine 1 is operatively connected to an electromagnetic powder clutch 2 so as to transmit the power of the engine 1 to a continuously variable belt-drive automatic transmission 4 through a selector mechanism 3. The output of the belt-drive transmission 4 is transmitted to axles 8 of vehicle driving wheels 9 through an output shaft 13, a pair of intermediate reduction gears 5, an intermediate shaft 6, and a differential 7.

The electromagnetic powder clutch 2 comprises an annular drive member 2a connected to crankshaft 10 of the engine 1, a driven member 2b secured to an input shaft 11 of the transmission 4, and a magnetizing coil 2c provided in the driven member 2b. Magnetic powder is provided in a gap between the drive member 2a and driven member 2b. When the magnetizing coil 2c is excited by the clutch current, driven member 2b is magnetized to produce a magnetic flux passing through the drive member 2a. The magnetic powder is aggregated in the gap by the magnetic flux and the driven member 2b is engaged with the drive member 2a by the powder. On the other hand, when the clutch current is cut off, the

drive and driven members 2a and 2b are disengaged from one another.

In the belt-drive transmission 4, the selector mechanism 3 is provided between the input shaft 11 and a main shaft 12. The selector mechanism 3 is provided with a synchromesh mechanism comprising gears, hub, and sleeve for connecting the input shaft 11 and the main shaft 12 to selectively provide a driving position (D-range) and a reverse driving position (R-range).

The continuously variable belt-drive automatic transmission 4 has the main shaft 12 and the output shaft 13 provided in parallel with the main shaft 12. A drive pulley 14 provided with a hydraulic cylinder 14a is mounted on the main shaft 12. A driven pulley 15 provided with a hydraulic cylinder 15a is mounted on the output shaft 13. A drive belt 16 engages with the drive pulley 14 and the driven pulley 15. Hydraulic cylinders 14a and 15a are communicated with an oil hydraulic control circuit 17. The hydraulic control circuit 17 is responsive to vehicle speed, engine speed and throttle valve position for controlling the amount of oil supplied to the cylinders 14a and 15a. The pulleys 14 and 15 are operated by compressive forces of cylinders so that the running diameter of belt 16 is varied to infinitely change the transmission ratio.

An electronic control system for the clutch 2 and the belt-drive transmission 4 has an engine speed sensor 19, and

rotating speed sensors 21 and 22 for respectively sensing speeds of drive pulley 14 and the driven pulley 15. A choke switch 24 produces an output signal when a choke valve of the engine 1 is closed, and an air conditioner switch 23 produces an output signal during operation of the air conditioner. A selector lever 25 connected to the selector mechanism 3 is provided with a select position sensor 26 for sensing the drive position D and reverse position R. An accelerator pedal switch 28 is provided for sensing the depression of an accelerator pedal 27, and a throttle position sensor 29 is provided.

Output signals of the sensors and pulses of the switches are applied to an electronic control unit 20 which produces a clutch current control signal to the clutch 2 and a control signal for controlling the transmission ratio (i) and a line pressure control singal to the control circuit 17.

Referring to Figs. 2a and 2b showing the control unit 20 of Fig. 1, a transmission ratio changing speed control section 30 is applied with a drive pulley speed signal N_P of the sensor 21, driven pulley speed signal Ns of the sensor 22, and throttle position signal θ of the sensor 29 to produce the transmission ratio control signal dependent on a desired transmission ratio changing speed di/dt. A line pressure control section 31 is applied with an engine speed signal Ne of the sensor 19, throttle position signal θ of the sensor 29, actual transmission speed ratio signal i (N_S/N_P) of the

transmission ratio changing speed control section 30 to produce the line pressure control signal dependent on a desired line pressure. These control signals are applied to the control circuit 17 to control the transmission ratio and line pressure of the transmission 4.

A reverse excitation mode deciding section 32 is applied with engine speed signal Ne of the sensor 19 and drive position signal of the select position sensor 26. When the engine speed Ne is below 300 rpm, or the selector lever 25 is at a neutral position (N-range) or a parking position (P-range), the reverse excitation mode deciding section 32 produces a reverse excitation signal which is applied to an output deciding section 33, so that a small reverse current flows in the clutch 2 to release the clutch completely.

A clutch current mode deciding section 34 is applied with signals from the reverse excitation mode deciding section 32 and accelerator pedal switch 28, and vehicle speed signal V from driven pulley speed sensor 22 for deciding driving conditions such as starting mode to produce output signals. The output signals are applied to a start mode providing section 35, drag mode providing section 36, and clutch lock-up engage mode providing section 37.

The start mode providing section 35 decides clutch current of starting characteristic dependent on the engine speed Ne at ordinary start or at closing of the choke switch 24 or air conditioner switch 23. The starting characteristic

is corrected by signals from the throttle valve opening degree θ, vehicle speed V, and driving positions of D-range and R-range.

The drag mode providing section 36 decides a small drag current when the accelerator pedal 27 is released at a low speed in each drive position for providing a drag torque to the clutch 2 for the smooth start of the vehicle.

The clutch lock-up engage mode providing section 37 decides a lock-up current in response to the vehicle speed V and throttle opening degree θ at each drive position for entirely engaging the clutch 2. Outputs of sections 35, 36 and 37 are applied to the output deciding section 33 to control the clutch current. A range of each mode is shown in Fig. 3.

Referring to Fig. 4, the clutch current mode deciding section 34 is provided with an accelerator pedal depressed mode section 40 and an accelerator pedal released mode section 41, each applied with output signals of throttle valve opening degree θ, vehicle speed V and reverse excitation mode deciding section 32. The accelerator pedal depressed mode section 40 is connected to a start mode deciding section 42 and lock-up engage mode deciding section 43. The mode is decided depending on whether the vehicle speed is higher or lower than a predetermined vehicle speed V_4 at which a lock-up current flows in the coil as shown in Fig. 3. Accordingly, respective output signals of the sections 42 and 43 are applied to the

start mode providing section 35 and lock-up engage mode providing section 37 through an output section 44. The accelerator pedal released mode section 41 is connected to a lock-up engage mode deciding section 45 and coasting deciding section 46. When the vehicle speed is below the predetermined speed V_4, the coasting deciding section 46 applied an output signal to the drag mode providing section 36 through an output section 47. When the vehicle speed is higher than the predetermined speed V_4, the lock-up engage mode providing section 37 is selected.

The accelerator pedal released mode section 41 is connected to a vehicle speed detecting section 49 and a vehicle speed increment calculator 48 to which the vehicle speed signal V is applied. The output signal of the calculator 48 that is increment ΔV and the output signal of the vehicle speed detecting section 49 that is vehicle speed Va are supplied to a downhill acceleration deciding section 50. When an increment ΔV of vehicle speed is larger than a predetermined value ΔV_S ($\Delta V \geqq \Delta V_S$) and the vehicle speed Va is higher than a predetermined value V_S which is lower than V_4 ($Va \geqq V_S$), it is decided that the vehicle is in downhill acceleration state at section 50. In response to the output signal of the section 50, the lock-up engage mode providing section is selected to lock-up the clutch.

Describing the operation of the system with reference to Fig. 5, the program is repeated at regular intervals. At a

step S1, it is detected whether the accelerator pedal is released. If it is detected at the step S1 that the accelerator pedal is depressed, the present speed V_a is set to an acceleration start vehicle speed V_c at a step S8 and the decision of the downhill acceleration state is cancelled at step S9. If the accelerator pedal is released, a present vehicle speed V_a and a vehicle speed V_b at the last program are compared with each other at a step S2. When the present vehicle speed V_a is lower than the previous speed Vb, the present speed V_a is set as acceleration start vehicle speed V_c at a step S3. When the present speed V_a is higher, the program directly advances to a step S4, where the increment ΔV of vehicle speeds is calculated from a formula $\Delta V = V_a - V_c$. At a step S5, the increment ΔV is compared with the predetermined value ΔV_s. If ΔV is larger than the ΔV_s, the present vehicle speed V_a is compared with a predetermined speed V_s. When the present speed is higher ($V_a \geqq V_s$), it is determined that the vehicle is in the downhill acceleration state at a step S7. Thus, the clutch is locked up, so that the engine braking is effected. At a step S10, the present vehicle speed V_a is set as the last vehicle speed V_b for the program.

Referring to Fig. 6, wherein the characteristic of the clutch current in accordance with the hereinbefore described operation is shown, at the start of the vehicle, when D-range or R-range is selected, a reverse current I_B becomes a small

drag current I_d. On the downhill, the vehicle is started without depressing the accelerator pedal in drag current mode and the vehicle is accelerated. When the vehicle speed exceeds the predetermined low speed V_s, the lock-up engage mode is selected so that a lock-up current I_L flows. Thus, clutch 2 is entirely engaged thereby providing an engine braking effect. The lock-up current I_L continues flowing as long as the vehicle speed increases. When the vehicle speed decreases below the speed V_s, the drag mode is selected so that the drag current I_d flows again.

On the other hand, when the accelerator pedal is depressed, downhill acceleration state is revoked and clutch current for starting the vehicle or lock-up current flows in dependence on the vehicle speed.

It will be understood that the present invention may be applied to other automatic clutches besides electromagnetic clutch.

According to the present invention, the clutch is entirely engaged when the vehicle is accelerated while coasting on downhills. Thus, sufficient engine braking effect can be provided to increase safety. Furthermore, under other driving conditions, both of suitable engine braking effect and coasting effect can be properly obtained by selecting proper clutch current.

While the presently preferred embodiment of the present invention has been shown and described, it is to be understood

that this disclosure is for the purpose of illustration and that various changes and modifications may be made within the scope of the appended claims.

CLAIMS

1. A system for controlling a clutch for a motor vehicle, wherein the clutch is normally engaged when vehicle speed is higher than a first reference speed, the system comprising:

first detecting means for detecting release of the accelerator pedal of the vehicle and for producing a corresponding release signal;

second means for detecting acceleration of the vehicle in the presence of the release signal and for producing an acceleration signal;

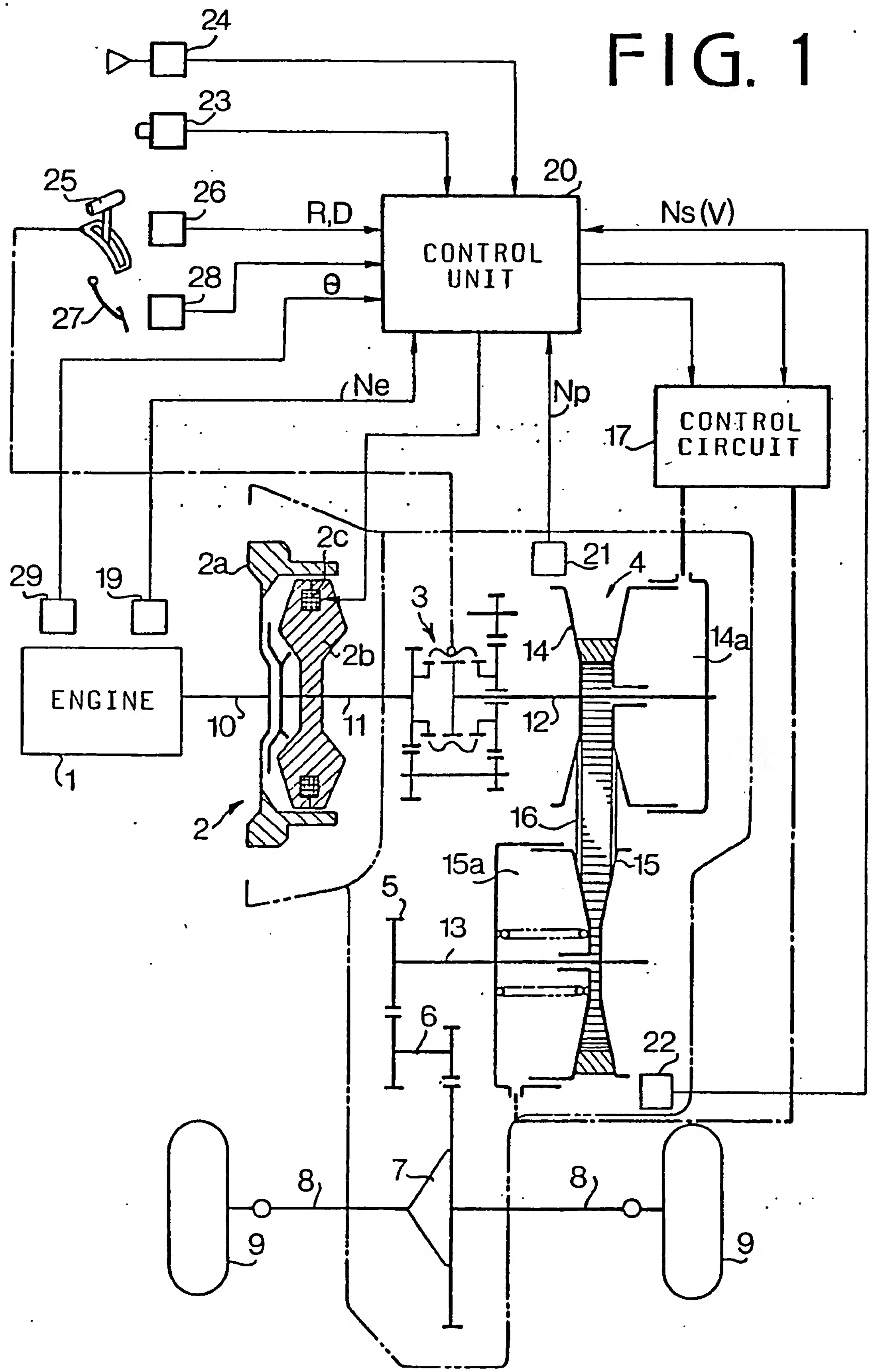
third means for detecting engine speed and for producing a downhill acceleration signal when the engine speed is higher than a second reference speed which is lower than the first reference speed;

and means responsive to the downhill acceleration signal for engaging the clutch.

2. A system according to claim 1 wherein the clutch is an electromagnetic clutch.

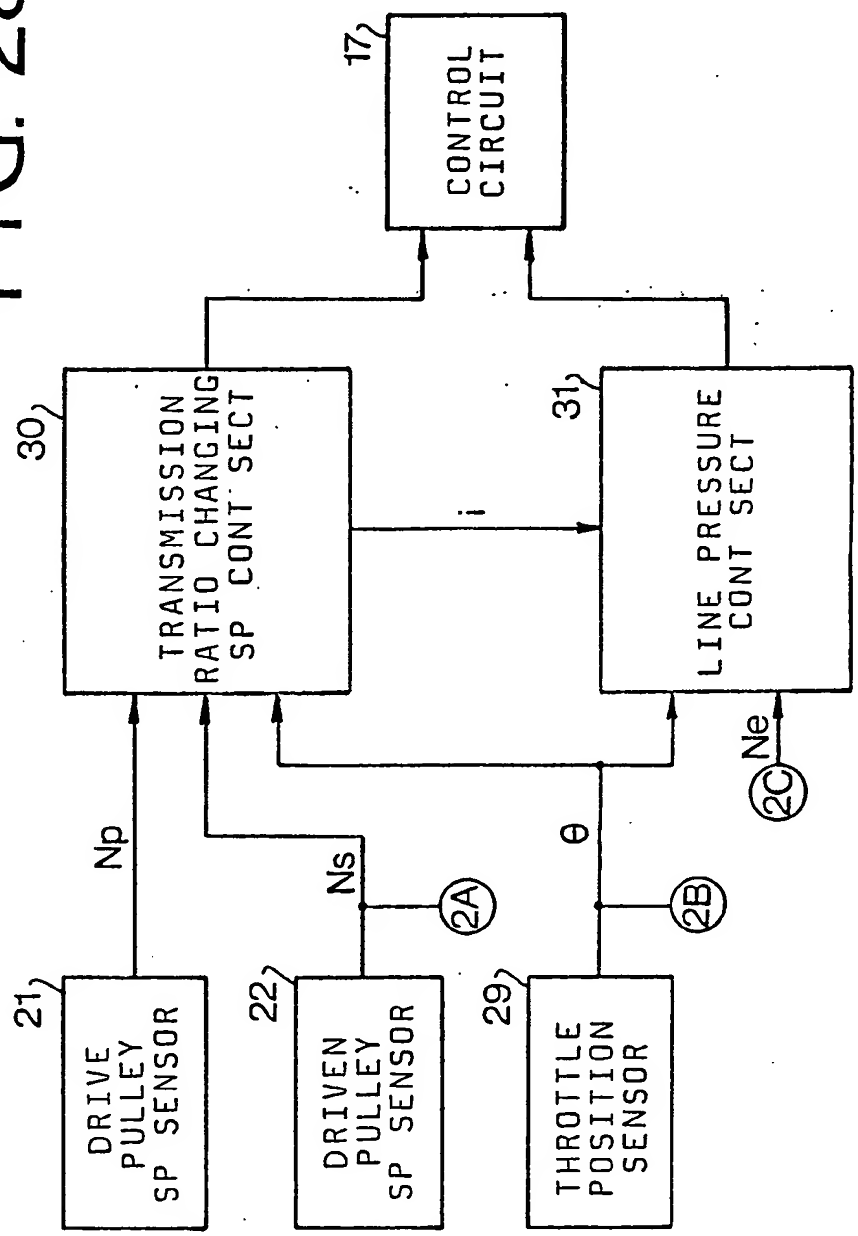
3. A system according to claim 1 wherein the means for engaging the clutch controls the current passing in the coil of the electromagnet.

FIG. 1



24
23
25
26
28
27
R,D
θ
20
CONTROL UNIT
Ns(V)
Ne
Np
17
CONTROL CIRCUIT
29
19
2a
2c
2b
3
21
4
14
14a
ENGINE
10
11
12
1
2
16
15a
15
5
13
6
22
7
8
8
9
9

FIG. 2a


17
CONTROL CIRCUIT
30
TRANSMISSION RATIO CHANGING SP CONT SECT
31
LINE PRESSURE CONT SECT
i
Ne
2C
θ
Np
Ns
2A
2B
21
DRIVE PULLEY SP SENSOR
22
DRIVEN PULLEY SP SENSOR
29
THROTTLE POSITION SENSOR

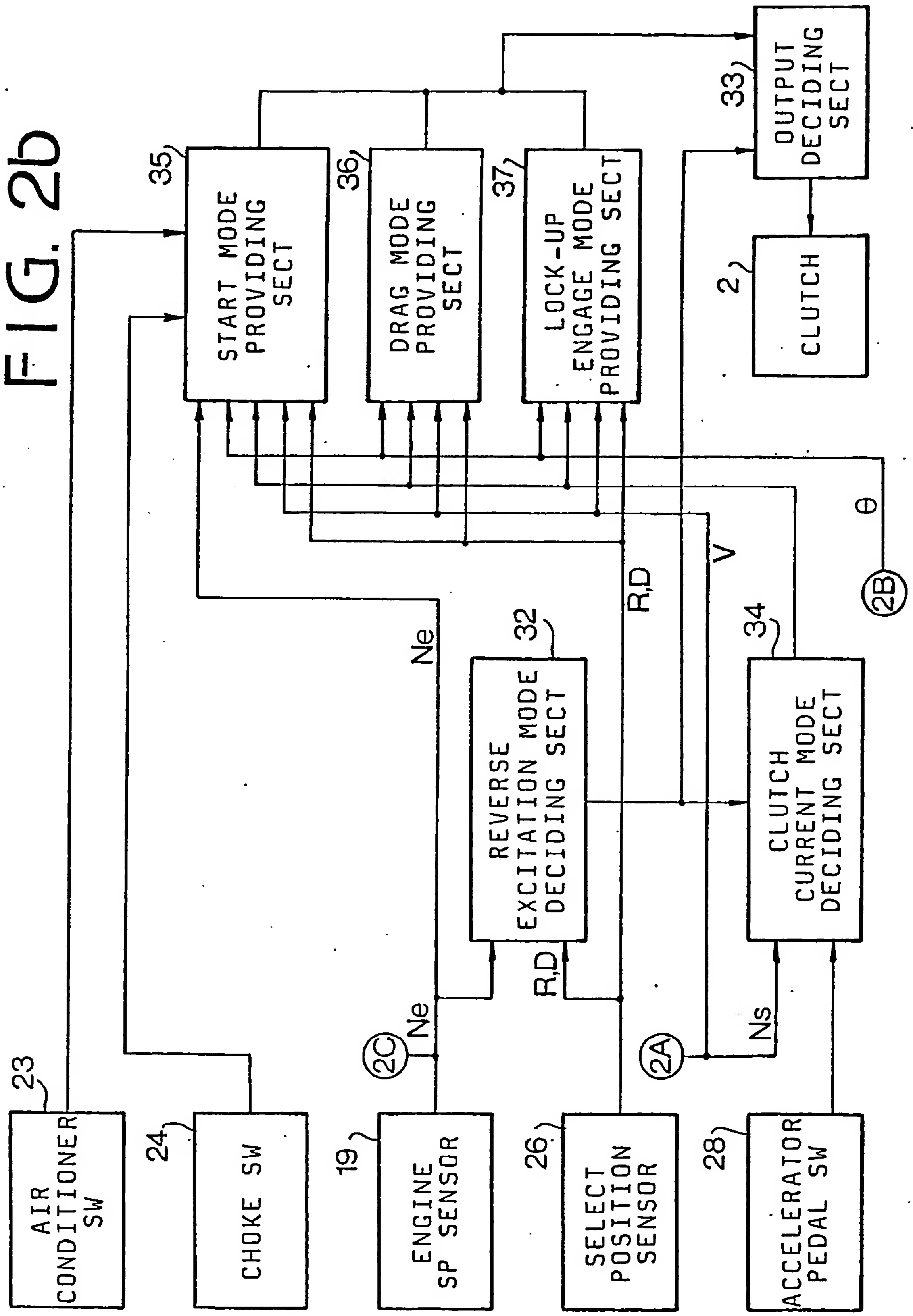
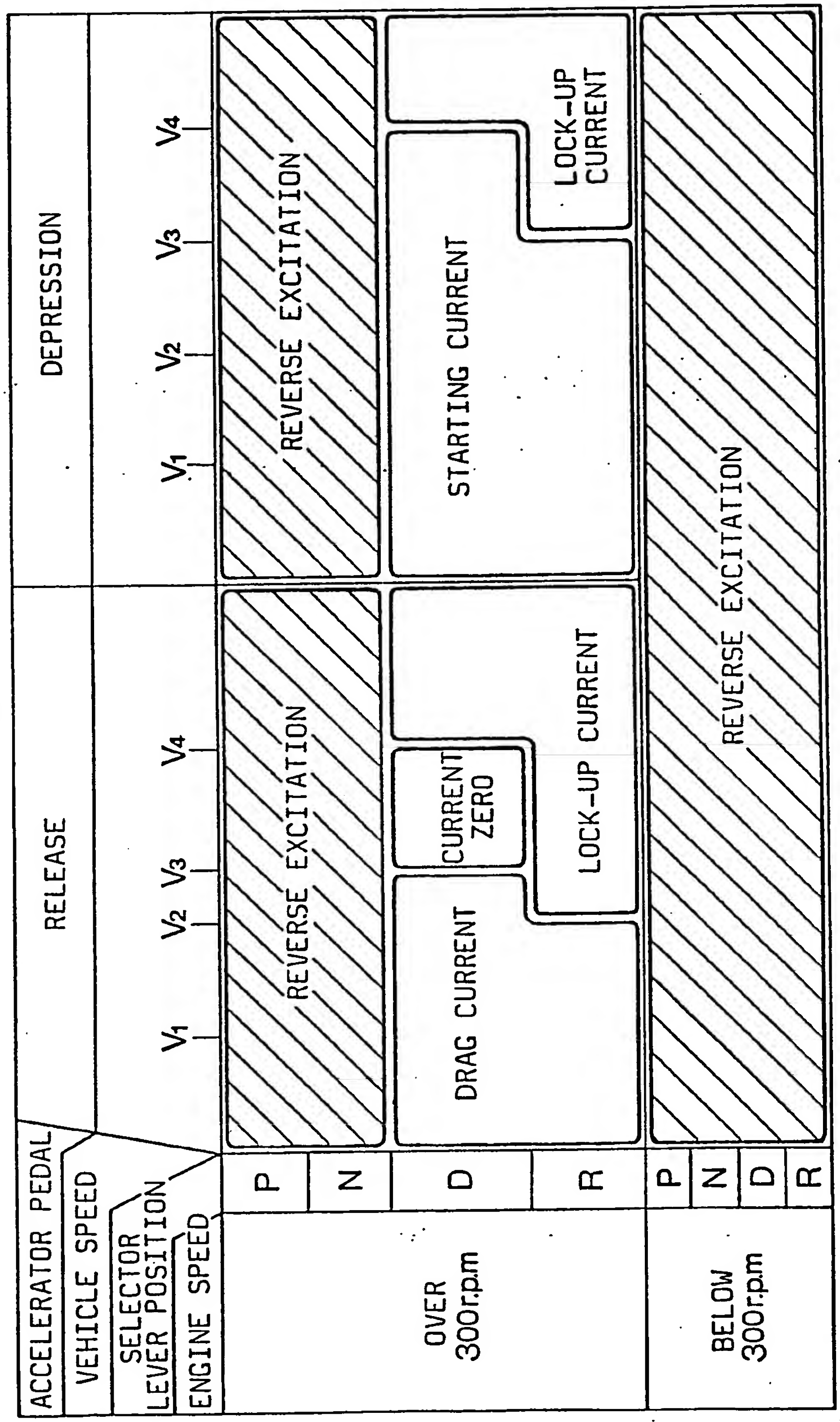

START MODE PROVIDING SECT
DRAG MODE PROVIDING SECT
LOCK-UP ENGAGE MODE PROVIDING SECT
OUTPUT DECIDING SECT
CLUTCH
REVERSE EXCITATION MODE DECIDING SECT
CLUTCH CURRENT MODE DECIDING SECT
AIR CONDITIONER SW
CHOKE SW
ENGINE SP SENSOR
SELECT POSITION SENSOR
ACCELERATOR PEDAL SW
35
36
37
33
2
32
34
23
24
19
26
28
Ne
Ne
R,D
R,D
V
θ
Ns
2A
2B
2C

FIG. 2b

FIG. 3


ACCELERATOR PEDAL
VEHICLE SPEED
SELECTOR LEVER POSITION
ENGINE SPEED
RELEASE
DEPRESSION
V1
V2
V3
V4
V1
V2
V3
V4
REVERSE EXCITATION
DRAG CURRENT
CURRENT ZERO
LOCK-UP CURRENT
REVERSE EXCITATION
STARTING CURRENT
LOCK-UP CURRENT
REVERSE EXCITATION
P
N
D
R
OVER 300r.p.m
P
N
D
R
BELOW 300r.p.m

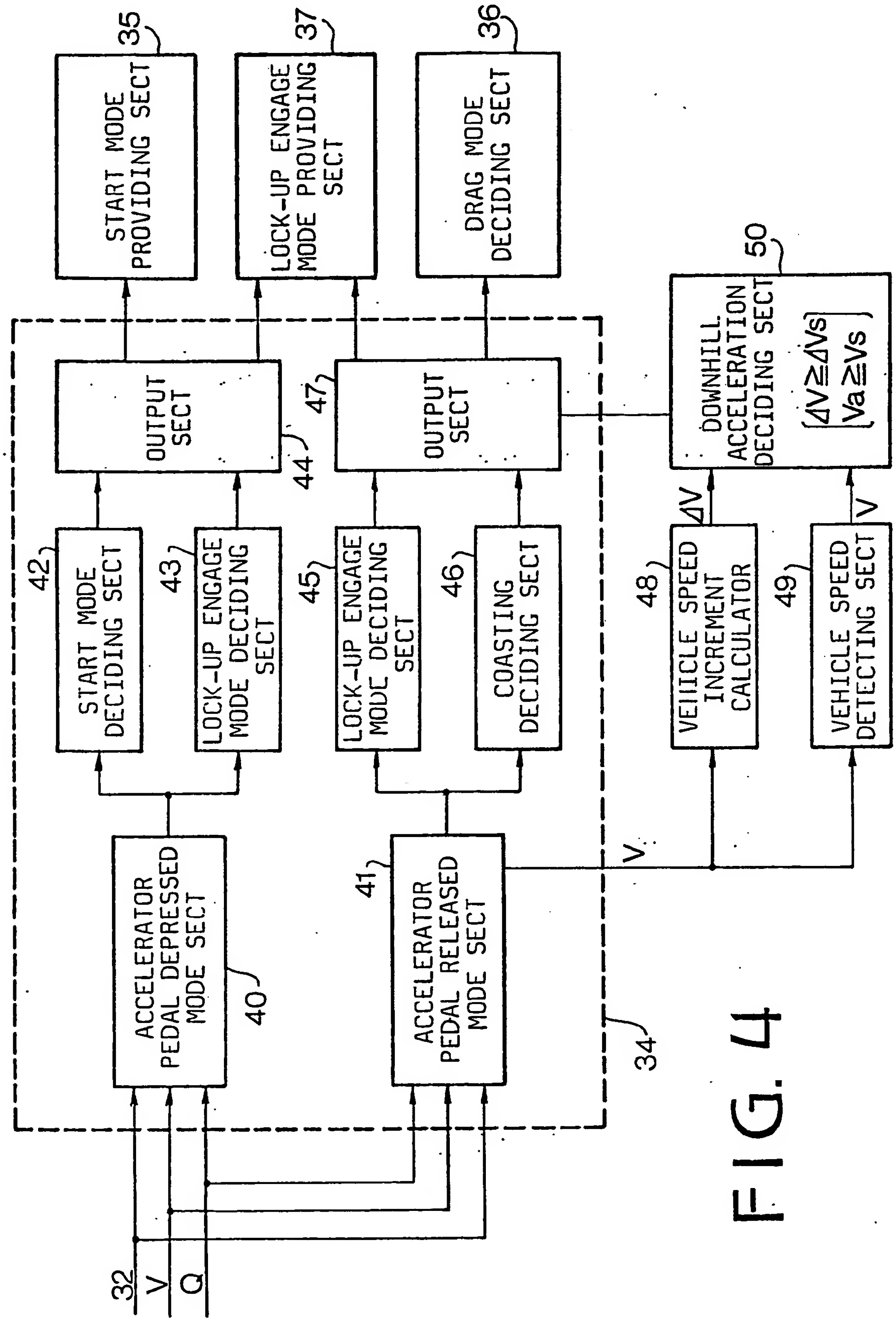

START MODE PROVIDING SECT
35
LOCK-UP ENGAGE MODE PROVIDING SECT
37
DRAG MODE DECIDING SECT
36
OUTPUT SECT
44
OUTPUT SECT
47
DOWNHILL ACCELERATION DECIDING SECT
[ΔV≧ΔVs
Va≧Vs]
50
START MODE DECIDING SECT
42
LOCK-UP ENGAGE MODE DECIDING SECT
43
LOCK-UP ENGAGE MODE DECIDING SECT
45
COASTING DECIDING SECT
46
VEHICLE SPEED INCREMENT CALCULATOR
48
ΔV
VEHICLE SPEED DETECTING SECT
49
V
ACCELERATOR PEDAL DEPRESSED MODE SECT
40
ACCELERATOR PEDAL RELEASED MODE SECT
41
V
34
32
V
Q

FIG. 4

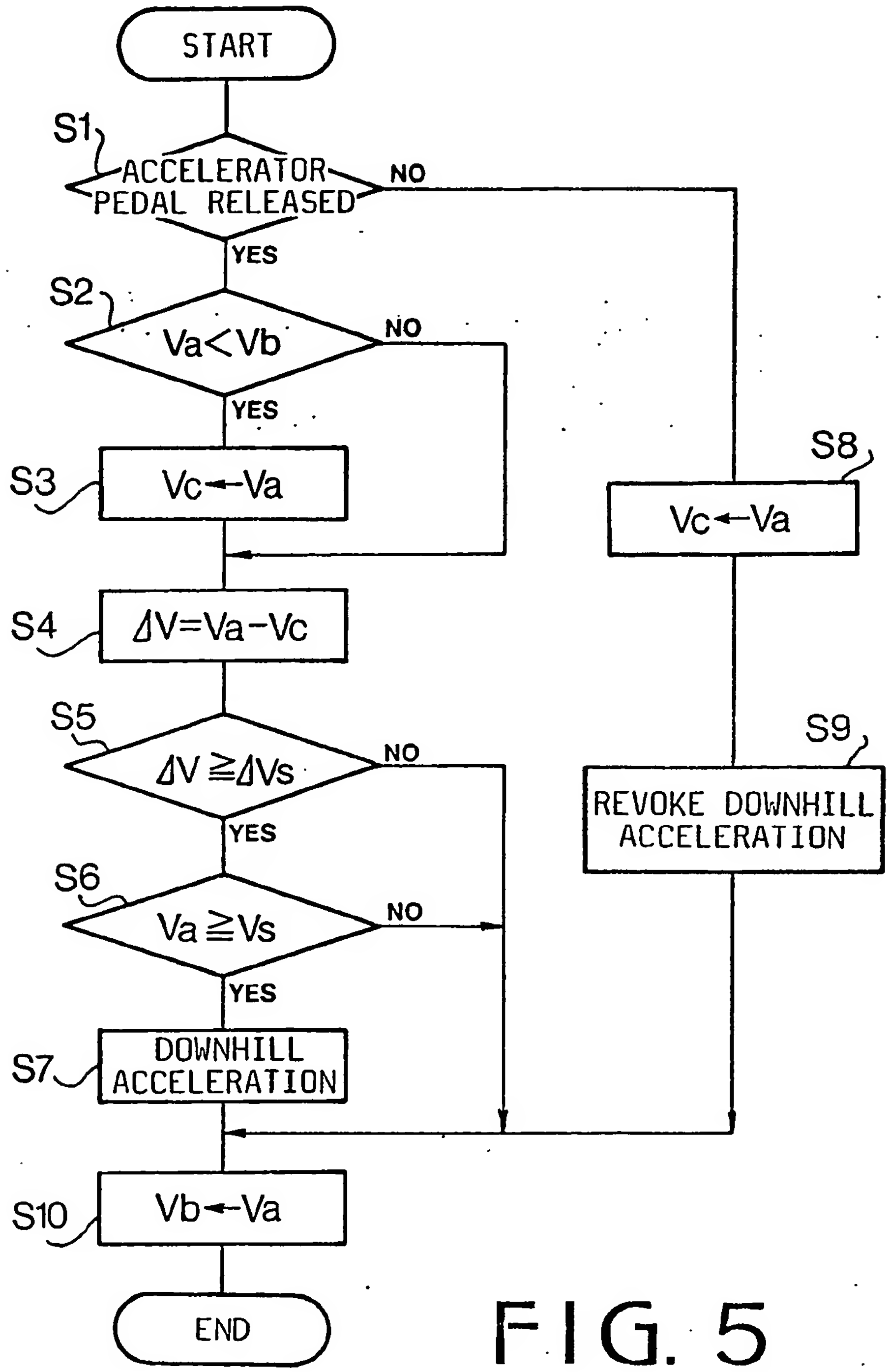

START
S1
ACCELERATOR PEDAL RELEASED
NO
YES
S2
Va<Vb
NO
YES
S3
Vc←Va
S8
Vc←Va
S4
ΔV=Va−Vc
S5
ΔV≧ΔVs
NO
YES
S9
REVOKE DOWNHILL ACCELERATION
S6
Va≧Vs
NO
YES
S7
DOWNHILL ACCELERATION
S10
Vb←Va
END

FIG. 5

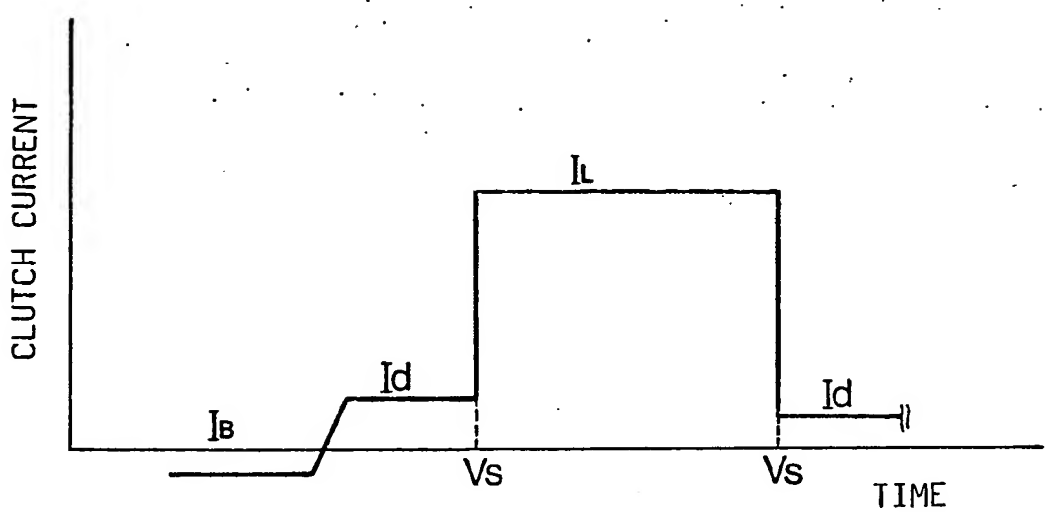


FIG. 6

a gear after the volume equalization. As a result, the shift can be performed with a reduced synchronizing force.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is further explained below with reference to the embodiments that are illustrated in the drawings, wherein:

Figure 1 represents a flowchart diagram for the initiation of a free-running phase;

Figure 2 represents a flowchart diagram for the exit from the free-running phase;

Figure 3 represents a flowchart diagram;

Figure 4 represents a schematic view of a motor vehicle; and

Figure 5 represents a flowchart diagram.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The flowchart diagram of Figure 1 serves to explain the initiation of a free-running phase. Block 1 represents an